

Working the World with Ham Digital Modes

By Larry Van Horn, N5FPW

Turn on your television set here in the States and you won't have to wait long for a commercial promoting the latest text messaging plan for various cellular telephone services. In fact, texting is the "in" thing to do these days. Walk around the office, at school, in a restaurant and you will see that everybody is texting.

But texting isn't limited to just a cellphone or Blackberry. You might be surprised to learn that in the ham radio world we have been texting long before it became popular among other portions of our populace.

With the advent of more powerful computers and the sound card, hams have been texting using digital modes since the end of 1998. Peter Martinez, G3PLX, was the first amateur to exploit the computer sound card by creating the PSK31 mode, a keyboard to keyboard digital mode that lets amateurs text each other via radio. Since that milestone event, sound cards have become more powerful and versatile, resulting in digital communications becoming one of the fastest growing segments of the amateur radio hobby.

In this article we will explore some of the newer digital modes currently being used by not only the amateur radio community, but some other inhabitants of the HF spectrum as well.

What do I need to get started?

If all you want to do is to receive some digital communications or if you are a shortwave radio listener, all you will need is a computer equipped with a sound card, an audio cable, a shortwave receiver with SSB capability, and a soundcard software package (see Table 1) that will decode the digital stream you want to receive.

If you are a licensed amateur radio operator, replace the receiver with a transceiver, add a hardware interface between the computer and the transceiver, and you can get in on the fun of working the world via digital modes.

The simplest and quickest computer to ham radio interface is to connect the line output from the sound card to the transceiver audio input with a 100:1 voltage divider to reduce the voltage

output, and the sound card line input to the audio output of the radio. You can use the transceiver VOX to switch from receive to transmit and back. You can learn more about this method on the WM2U website (see our resource guide, Table 2).

If you want to roll your own interface, Jack, KE0VH, has an interesting website with information on building a computer to transceiver interface. If you can read a schematic, have a few junk parts and can handle a soldering iron, then his ham brewed project may be just what you need to get into the fun of digital ham radio without breaking the bank.

If you have two thumbs, burn yourself frequently with a soldering iron, or just have some cash to spare, you can purchase one of the commercial interface units that are available in the ham radio marketplace. Manufacturers such as MFJ, RigExperts, Saratoga, Tigertronics, and West Mountain Radio all make inexpensive interface units (see our link to the DX Zone Digital and Packet Radio Resource Guide).

When setting up to transmit or receive, sound card digital modes are used using upper side band (USB). Do not use LSB. The older, more conventional digital modes such as Clover, RTTY, PACKET, AMTOR and PACTOR typically use LSB.

Before we move on, there is one important point that needs to be mentioned. Most of the problems in setting up the computer, interface, and radio can be attributed to the proper setup of the sound card and mixer panels on the computer. Del Schier, K1UHF, wrote an excellent article on all of this in the October 2003 issue of *QST*.

The good people at West Mountain Radio have made this article available in Adobe PDF form on their website. I highly recommend you download this file (link in our Resource Guide) and study it thoroughly. It will save you a lot of time and grief when you start setting up your station to work the various digital sound card modes.

Digital Modes

The rate of software and hardware development has moved so fast that it is nearly impossible for even an article with short turn-around



Saratoga's EZ PSK USB Interface

to keep up with the rapid changes in the ham digital world. If you want the latest information I recommend subscribing to the Digital Radio newsgroup based on the Yahoo website (see resource guide).

On the other hand, there are some digital modes that are the staple of the digital ham community. CW and RTTY are still widely used. These modes are widely supported by quite a few of the software decoder packages in our sampler in Table 2.

Other modes that have been in common use by the amateur radio community over a number of years include: AMTOR, APRS, Clover, G-TOR, Packet, PACTOR I (DOS freeware package that requires a PSA chip set sound card and will not do Airmail, Sailmail or WinLink2000), and Slow Scan Television (SSTV).

A lot of reference material is already available on the Internet and in printed form regarding these modes, so I won't cover them in-depth in this article. If you want more information

Key to Abbreviations/Acronyms

| | |
|------|---------------------------------------|
| BPSK | Binary Phase-Shift Keying |
| CW | Continuous Wave (aka Morse code) |
| DSP | Digital Signal Processing |
| FEC | Forward Error Correction |
| IFK | Incremental Frequency Keying |
| MFSK | Multi-Frequency Shift Keying |
| PSK | Phase Shift Keying |
| QPSK | Quadrature Phase-Shift Keying |
| QRM | Interference |
| QRP | Low Power |
| RTTY | Radio Teletype |
| SSB | Single Side Band |
| WARC | World Administrative Radio Conference |

on these modes, an excellent reference is the ARRL's *HF Digital Handbook* by Steve Ford, WB8IMY (see the February *MT What's New* column, page 74).

The Sound Card Revolution

It was the mode that started the amateur radio sound card digital mode revolution and is still today the big daddy of them all: the PSK31 mode.

Phase modulation communication modes have many more advantages than the CW mode, which uses amplitude (On/Off) keying. In a noisy or distorted propagation environment, the amplitude of a signal will shift and vary much more than the phase of a signal. When compared to CW, PSK31 is a much more reliable operating mode.

PSK31 uses a varicode character coding that provides the operator with a top data rate of around 50 wpm (31.25 baud). Instead of using FSK or on/off keying, PSK31 uses Binary or Quadrature Phase-Shift Keying with a Viterbi decoder. Based on a RTTY style of operation, this mode is most useful for live keyboard to keyboard conversations at 31.25 baud (31 Hz bandwidth). It is easy to use and monitor, highly immune to noise and QRM, and is suitable for low power (QRP) operations.



The MFJ-1275 Sound Card Interface

Software packages used to operate in this mode are available for free for many computer platforms, including Windows with Sound Blaster type soundcards.

There are several variant modes of PSK that hams are now using on the bands. Some of the variant modes include:

- BPSK:** PSK31 (31.25 baud) PSK63 (62.5 baud) PSK125 (125.0 baud)
- QPSK:** QPSK31 (31.25 baud) QPSK63 (62.5 baud) QPSK125 (125.0 baud)
- PSK-F:** PSK63F (62.5 baud) PSK125F (125.0 baud) PSK220F (220.5 baud)
- PSK-FEC:** PSK31FEC (31.25 baud)
- PSK10:** PSK10 (10.0 baud)
- PSKAM:** PSKAM10 (10.0 baud) PSKAM31 (31.25 baud) PSKAM50 (50.0 baud)
- PSK-Hell:** PSK-Hell-105 (105.0 baud) PSK-Hell-245 (245.0 baud)
- GMSK:** GMSK31 (31.25 baud) GMSK63 (62.5 baud)
- CHIP:** CHIP64 (300.0 baud) CHIP128 (300.0 baud)



RIGblaster Models

- MT63:** MT63 500 Hz (5.0 baud) MT63 1000 Hz (10.0 baud) MT63 2000 Hz (20.0 baud)
- Q15X25:** Q15X25 (15 x 83.333 baud)

You can expect to find PSK digital communication in and around the following HF/VHF/UHF frequencies:

- HF – 1838 3580 7035 (ITU Region 1) 7070 10140 14070 18100 21080 24925 28120 kHz
- VHF/UHF – 50.290 144.144 222.070 432.200 and 909 MHz

A CHIP off the old PSK block.

One of the PSK modes mentioned above that is heard occasionally in the ham bands is the CHIP 64/128 mode. CHIP 64/128 is a Direct Sequence Spread Sequence (DSSS) mode using an original algorithm. CHIP 64/128 is a very robust mode, getting through when conditions are poor.

In the United States, 7090.0 kHz USB appears to be the most active frequency CHIP frequency, but 14077.0 and 14110.0 kHz have also been reported.

Be aware that on 7090.0 kHz there is also Olivia (see section below) activity. Olivia has a chirpy sounding tone, a kind of combination of MFSK16 and SSTV sounding signals. Chip 64 is nothing like this: It is more a "whooshing" or "roaring" white noise type of signal, not as low in tone as MT63.

Is it Analog or Digital?

The Hellschreiber mode was invented by Dr. Rudolf Hell in 1929. It was an early form of facsimile communications where only upper case letters were transmitted and received. It was used by the Germans during WW2 and some receivers were built by the British and Americans to intercept enemy communications.

In the late 1990s, hams have emulated the mode using computer sound cards. The resulting mode is referred to by the amateur radio community as Hellschreiber, Feld-Hell, or simply Hell. We also refer to this mode and its variants as the fuzzy modes.

Hellschreiber is an asynchronous transfer mode where the signal is discretely coded. This means two things:

- It is transmitted with either an on or off signal.
- The transmitter does not tell the receiver how fast it transmits. It simply sends the message in its own speed and the receiver must do its best.

There was a bit of a dust-up among the digital community regarding the Hell modes. A debate initially raged whether Hellschreiber should be considered an analog or digital mode. Regardless of what type of mode you want to call it, Hell has a small, but devoted following.

There are several Hell variants and these include:

Feld Hell is the traditional Hell mode with a baud rate of 245 baud but, in fact, it is a

pseudo-122.5 baud (one "pixel" is 8.163 ms long).

PSK Hell encodes the pixel's brightness in the carrier phase instead of the amplitude. Strictly speaking, it's encoded in the change of the phase (differential phase shift keying): an unchanged phase in the beginning of a pixel means white, and a reversed phase means black. It operates at 105 or 245 baud. It has the same traits as standard PSK31 including its great sensitivity. Great for DX work in bad QRM. It is, however, sensitive to drift.

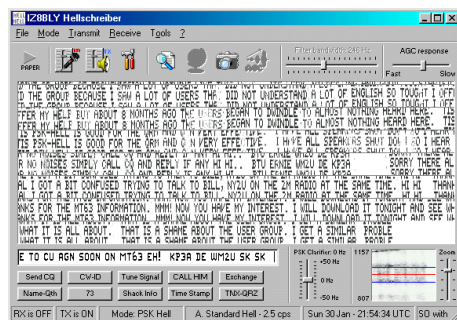
FM Hell uses frequency modulation with a careful control of phase, essentially minimum-shift keying.

Duplo Hell is a dual tone mode which sends two columns at a time at different frequencies (980 Hz and 1225/1470 Hz). Wide shift, but better immunity to noise. LSB recommended.

C/MT Hell or concurrent multitone Hell sends all rows at the same time using tones at different frequencies. The transmission can be read using an FFT display. It allows for high resolutions. Not very sensitive, but it has great noise immunity.

S/MT Hell or sequential multitone Hell is like C/MT but with a discrete number of tones (characters are restricted to 5x7 pixels).

Slowfied is a very slow mode (2 characters per minute) intended for beacon use.



A screen capture of Hellschreiber mode

You will find most Hell mode activity concentrated around these frequencies:

- 3559 3590 7063 10135 14063 18063 21063 24963 28063 28110 kHz

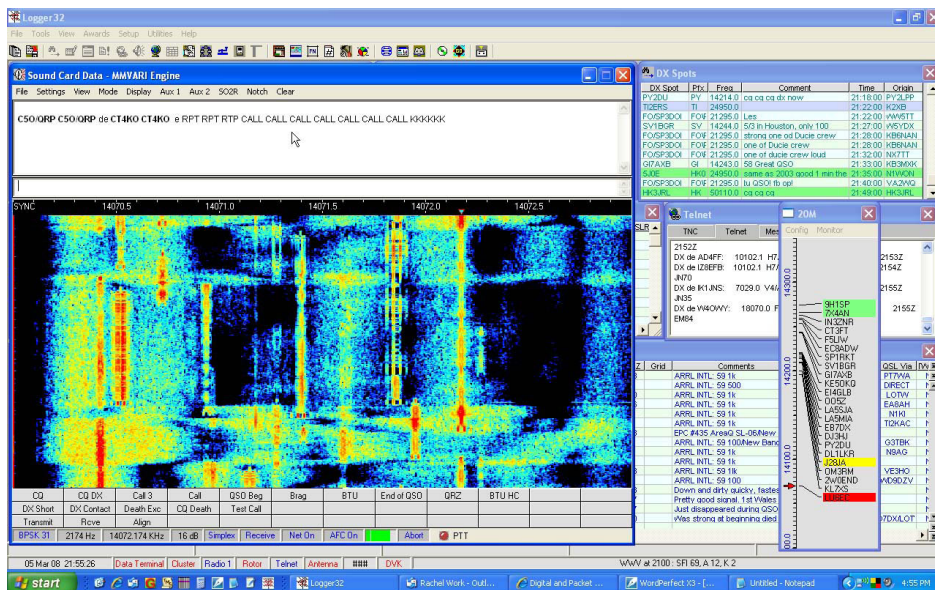
MFSK – The Super RTTY

Until recently, few hams had even heard of MFSK, while some that had may have dismissed MFSK as being "old fashioned." MFSK was used successfully by the British Foreign Office, the Belgian and French military, and others. Some of you may recognize this mode by its other names – Coquelet and Piccolo.

As has been clearly demonstrated by the recent successful revival and acceptance of Hellschreiber, old ideas combined with modern techniques such as DSP can prove to be very effective.

MFSK is a technique for transmitting data using multiple tones. Unlike RTTY with its two-tone method of data delivery, MFSK sends many tones, usually, but not always, one tone at a time.

There are a number of different techniques, using concurrent (or parallel) tones, sequential (one after another) tones, and com-



Logger32 screen capture of BPSK31 mode

binations of tones. MFSK transmissions have a unique sound, almost musical, which is why Piccolo and Coquelet received their names. (Coquelet means rooster.)

You will encounter three variants in the MFSK family. MFSK16 uses 16 tones and has a baud rate of 15.625 baud. It was first showcased in a software package known as *Stream*. Another variant is MFSK8 which has a baud rate of 7.8125 baud and uses 32 tones.

MFSK SSTV is a slow scan TV mode without transmission of a synchronization ray, in color or in black and white mode, where the picture may be transmitted among MFSK16 text. The picture format is not fixed as in classical SSTV, but is variable (and limited to small pictures).

MFSK modes have an excellent tolerance for ionospheric effects such as Doppler, fading and multi-path. Most important of all, with an MFSK system, the error rate improves as the number of tones is increased. So with as many as 32 tones (MFSK8), the performance is unrivaled. With PSK systems the opposite is true.

Look for MFSK activity around these frequencies:

10148 14080 18105 21063 kHz USB

Other MFSK Type Modes

A new MFSK mode that uses incremental frequency keying (IFK) has been created by Murray Greenman, ZL1BPU, and is known as **DominoEX** and **DominoF** (with FEC coding). It is a simple amateur radio mode that is popular for keyboard to keyboard conversations. Unlike other MFSK modes, Domino will handle TX/RX offsets and mistuning of up to 200-Hz with ease, and will provide perfect copy of drifting signals up to 200-Hz per minute.

DominoEX sends short bursts using 18 different tones at one time. Each tone carries four bits of data. By using IFK, DominoEX overcomes problems with frequency stability and tuning accuracy that plague other MFSK modes.

The following is a list of known Domi-

noEX variants:

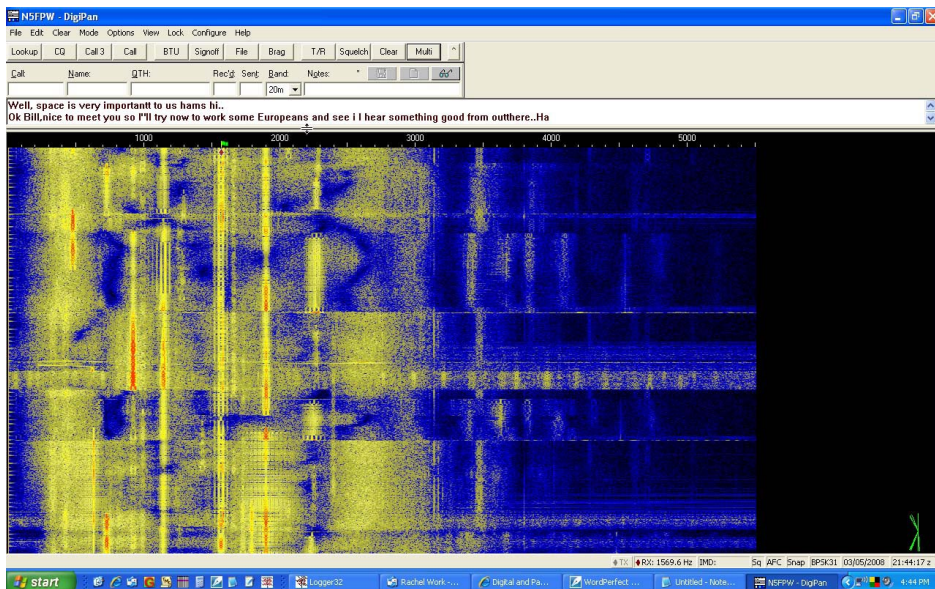
| Mode | Baud | Bandwidth | Speed |
|-------------|----------|-----------|----------|
| DominoEX 4 | 3.90625 | 173 Hz | ~25 wpm |
| DominoEX 5 | 5.38330 | 244 Hz | ~31 wpm |
| DominoEX 8 | 7.81250 | 346 Hz | ~50 wpm |
| DominoEX 11 | 10.76600 | 262 Hz | ~70 wpm* |
| DominoEX 16 | 15.62500 | 355 Hz | ~100 wpm |
| DominoEX 22 | 21.53300 | 524 Hz | ~140 wpm |

* the default speed for this mode.

The DominoEX digital modes shine the best in the lower ham bands (30, 40, 80 and 160 meters) where multipath reception is an issue.

Another MFSK type mode is **Olivia**, which is becoming very popular in the amateur radio community. Olivia is one of the most robust methods of text keyboarding, performing superbly for long distance communications. Conversations can take place with nearly 100% copy even when signals are 10 dB below the noise floor. Many Olivia operators report perfect copy even when the signal audio is completely inaudible.

An Olivia signal consists of two layers of



Digipan software's rendering of BPSK31 mode

code. One is an FEC code using MFSK. The second is another FEC code based on a mathematical analysis known as Walsh functions.

Look for Olivia activity on 20 meters between 14105 and 14109 kHz. More information on Olivia frequencies, format and software can be found on the HFLink website (see resource section).

Then there are the **Throb** and **ThrobX** modes. Developed by Lionel Sear, G3PPT, these two modes take their names from the "throbbing" sound their signals make on the air. ThrobX is an evolution of Throb.

The baud rate is very slow 1 or 2 baud using 11 tones with two tones sent at the same time (which gives 55 possibilities including the two possible idle characters).

Look for Throb and ThrobX along with the other MFSK modes (MFSK16, MFSK8, Throb, ThrobX, DominoF, DominoEX) around the following frequencies:

1838.0 3580.0 7037.0 10147.0 14080.0
18105.0 21080.0 24929.0 28080.0 kHz

The WSJT Modes

WSJT is not a mode, but it is a computer program with modes for amateur VHF/UHF communication using state of the art digital techniques. Developed by Joe Taylor, K1JT, the WSJT program can help you to make contacts using fraction-of-a-second signals reflected from meteor trails, as well as steady signals more than 10 dB weaker than those needed for conventional CW. WSJT supports five principal operating modes:

FSK441 is used for meteor scatter communications

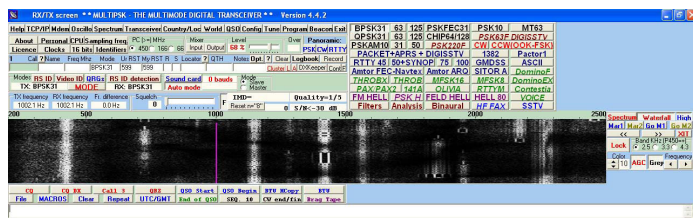
JT65 is used for EME and other extremely weak signals.

JT6M is used for meteor and ionospheric scatter (optimized for 50 MHz).

EME Echo is used for measuring your own echoes from the Moon

CW is used for EME QSOs using 15 WPM Morse code

You will find much more on the WSJT modes on Joe Taylor's website (address in re-



Digital MultiPSK software screen capture

source section).

A final digital thought...

The world of amateur radio digital communications has grown by leaps and bounds in the last five years, and shows no signs of slowing down. It is a lot of fun to make a contact with a fellow ham using low power and receiving a weak signal. It is even more fun to carry on an international text conversation with others all over the world.

So check out our resource list, download some software, and give the digital modes a listen. I guarantee you won't be on the sidelines long. CU on my waterfall soon.

Table 1 – Digital Modes Program Sampler

| Program | URL |
|---------------------------|---|
| AAVoice | www.dxsoft.com/en/products/aavoice/ |
| ACARS | www.airnavsystems.com/ |
| AGW Packet Engine | www.agwtracker.com/ |
| APRS | www.winaprs.org/ |
| Blaster SSTV | www.hampubs.com/sstvwith.htm |
| Blaster Teletype | www.geocities.com/SiliconValley/Heights/4477/?20085 |
| Cluster Blaster | www.qrz.com/mftp/morse/cb_217.zip |
| CW Decoder | www.amqrp.org/projects/cwdecod/decoder.htm |
| CWGet | www.dxsoft.com/en/products/cwget/ |
| CWType | www.dxsoft.com/en/products/cwtype/ |
| DigiPan | www.digipan.net/ |
| DigiPic | www.qsl.net/kh6ty/digipic/ |
| DigiTalk | www.qsl.net/kh6ty/digitalk.htm |
| DIGTRX | http://paginas.terra.com.br/lazer/py4zbz/hdsstv/teste1.html |
| DSC Plotter* | www.coaa.co.uk/dscdecoder.htm |
| DX PSK | http://dxfile.free.fr/dxpsk.htm |
| EPiRB Plotter* | www.coaa.co.uk/epirbplotter.htm |
| EXTFSK | http://mmhamsoft.amateur-radio.ca/extfsk.htm |
| Fldigi (Linux) | www.w1hkj.com/Fldigi-2.x.html |
| FlexNet | www.afthd.tu-darmstadt.de/~flexnet/ |
| FTV | http://ftv.3amsystems.com/ |
| gMFSK (Linux) | http://gmfsk.connect.fi/ |
| Ham Dream (DRM) | www.qsl.net/de/member/hb9ilk/ |
| Ham Fax (Linux) | http://hamfax.sourceforge.net/ |
| HDSSTV | www.svs.net/wyman/examples/hdsstv/0q.htm |
| Hellschreiber | http://xoomer.alice.it/aporcino/Hell/index.htm |
| HF (Linux) | www.baycom.org/~tom/ham/linux/hf.html |
| Intercom | http://pa3byz.uwnet.nl/ritymade.htm |
| HamScope | www.qsl.net/hamscope/ |
| Jason | www.weaksigals.com/jason/ |
| JVComm32* | www.jvcomm.de/ |
| Logger 32 | www.logger32.net/ (Now includes the Zakanaka digital program) |
| MacAPRS (MacIntosh) | www.winaprs.org/MacAPRS.htm |
| MacMultiMode* (MacIntosh) | www.blackcatsystems.com/software/multimode.html |
| MixW* | http://mixw.net/ |
| MMTTY | http://mmhamsoft.amateur-radio.ca/mmtty/index.html |
| MMSSTV | http://mmhamsoft.amateur-radio.ca/mmsstv/ |
| MRP40 | www.polar-electric.com/Morse/MRP40-EN/index.html |
| Mscan Meteo | http://mscan.com/products.html |
| Mscan SSTV | http://mscan.com/products.html |
| MT63 | http://xoomer.alice.it/aporcino/MT63/index.htm |

| | |
|--------------------------------|--|
| Multimon* (Linux) | www.baycom.org/~tom/ham/linux/multimon.html |
| MultiPSK* | http://members.aol.com/f6cte/index_anglais.htm |
| N1MM Logger | www.n1mm.com/ |
| NBTv 32 Line | www.qsl.net/g4hbt/nbtv/nbtv32.zip |
| NDB Finder* | www.coaa.co.uk/ndbfinder.htm |
| Orbcomm Plotter* | www.coaa.co.uk/orbcommplotter.htm |
| Phase Shift (Linux) | www.qsl.net/n1vtn/phaseshift.html |
| PC ALE | www.chbrain.dircon.co.uk/pcalc.html |
| PC HFDL* | www.chbrain.dircon.co.uk/pchfdl.html |
| Plane Plotter* | www.coaa.co.uk/planeplotter.htm |
| Precision CW | www.qsl.net/dj7hs/download.htm |
| PSK31 SBW | www.qsl.net/wm2u/p31sbw108.zip |
| PSK63 | www.qsl.net/kh6ty/psk63/ |
| PSK Software by Peter Martinez | www.aintel.bi.edu.es/software.html |
| QSSSTV | http://users.telenet.be/on4qz/ |
| RadioCom* | www.bonito.net/ |
| RCKrty | www.rckrty.de/ |
| SeaTTY | www.dxsoft.com/en/products/seatty/ |
| Selcal | www.airnavsystems.com/ |
| Ship Plotter* | www.coaa.co.uk/shipplotter.htm |
| SkySweeper* | www.skysweep.com:80/ |
| SlowFeldXPAS | www.lsear.freemove.co.uk/aircraft%20scatter.htm |
| Smart PSK | http://dxfile.free.fr/dxpsk.htm |
| StaRCV (AO-40 FEC decoder) | www.amsat.org/amsat/sats/ao40/fec.htm |
| Stream (MFSK8/16) | http://xoomer.alice.it/aporcino/Stream/index.htm |
| Train Plotter* | www.coaa.co.uk/trainplotter.htm |
| TrueTTY | www.dxsoft.com/en/products/trueTTY/ |
| TWCW (Linux) | http://wa0eir.home.mchsi.com/ |
| TWPSK (Linux) | http://wa0eir.home.mchsi.com/ |
| UI-View | www.ui-view.org/ |
| Voice Key Express | www.qsl.net/n7qjp/ |
| W1SQLsk | www.faria.net/w1sql/psk31.htm |
| Wdecode | www.xs4all.nl/~yskes/progcom/index.html |
| WinAPRS | www.winaprs.org/downloads/WinAPRS/ |
| WinDRM | http://n1su.com/windrm/ |
| WinMSDSP | www.qsl.net/w8wn/hscw/msdsp.html |
| WinPix32 | http://hjem.get2net.dk/sstv/sstv2.htm |
| WinPSK | www.moetronix.com/ae4jy/winpsk.htm |
| WinPSKSE | www.hamsource.com/winpskse/ |
| WinSkan | http://webpages.charter.net/jamie_5/ |
| WinWarbler | www.dxlabsuite.com/winwarbler/ |
| WOLF | www.scgroup.com/ham/wolf.html |
| WO-PSK | www.qsl.net/zs5wo/ |
| WriteLog | www.writelog.com/ |
| WSJT | http://physics.princeton.edu/pulsar/K1JT/ |
| WS Tools (Linux) | www.qsl.net/g4klx/software.htm |
| WXSAT | www.hffax.de/ |
| Wyman1x | www.svs.net/wyman/examples/hdsstv/index.htm |
| X-APRS (Linux) | www.winaprs.org/xaprs.html |

*includes digital modes not used by amateur radio operators

Table 2 – MT Digital Resource Guide

| | |
|---|--|
| AC6V Digital Modes Software List | http://ac6v.com/software.htm#DIGITAL |
| Amateur Radio Sound Blaster Software Collection | www.muenster.de/~welp/sb.htm |
| Digital and Packet Radio Resource Guide | www.dxzone.com/catalog/Manufacturers/Digital_and_Packet_Radio/ |
| Digital Radio | www.Yahoogroups.com |
| Digital Voice on HF | www.chbrain.dircon.co.uk/dvhf.html |
| DominoEX | www.qsl.net/zl1bpu/DOMINO/Index.htm |
| KE0VH Digital Interface Project | www.hamuniverse.com/ke0vhproject.html |
| Olivia – The Magic Band | http://hflink.com/olivia/ |
| PSK31 and other PC Magic | www.psk31.com/ |
| PSK31 by WM2U | www.qsl.net/wm2u/psk31.html |
| PSK31 Official Homepage | http://aintel.bi.edu.es/psk31.html |
| PSK Handbook | www.buxcomm.com/pdfzips/pskhandbook.pdf (a must read) |
| Sound Card Interfacing by WM2U | www.qsl.net/wm2u/interface.htm |
| The In's and Out's of a Sound Card | www.westmountainradio.com/pdf/Ins&Outs.pdf |
| West Mountain Radio Software Links | www.westmountainradio.com/links.htm |
| WSJT Website | http://physics.princeton.edu/pulsar/K1JT/ |